No. 130

September 2006

solplan review

the independent journal of energy conservation, building science & construction practice

Inside . . .

Rain Screen Walls

From the Editor . . .

Our industry talks a lot about housing quality, affordability and choice to build vibrant, prosperous and healthy communities. A key talking point focuses on lower taxes, as if that will be the magic bullet that will lower prices and increase housing affordability.

Although taxes and development charges are a significant factor in housing prices, we must also acknowledge that these fees are a charge for community infrastructure and services that make our communities livable. We may whine about taxes, but we expect to have highways, bridges, policing, firefighting services and countless other services available for all. All of these services have to be paid for somehow. Despite rhetoric to the contrary, most of these services belong in the public domain and are provided cost effectively by the public sector, hence the need for the taxes and fees. One may question the value for money offered by the taxes, although that is seldom done with any rigour. Perhaps true open accountability of public spending and the standard of service is where that energy should be directed.

Being champions of the home-buying consumer we mount campaigns in favour of tax reduction, but I don't see any campaign to question rising expectations. I think that we, as an industry, have helped change consumer expectations to unrealistic levels. We can provide quality and affordability, but does quality require marble and granite countertops? Does every house really need 4 or 5 bathrooms, especially as most of the time there are only two or three people rattling about in the house? Do we really need 800-900 square feet or more per person for a livable home? Super-sizing doesn't just apply to the fast food chains – our houses have moved in that direction too.

When 'affordability' is being bandied about, the real fundamentals are being overlooked. Affordability is not just impacted by taxes and fees, but perhaps more so by expectations. Using today's superior construction standards, most of us could build good quality affordable houses of the type many in the post-World War II generation grew up in. Those post-war homes were simple, modest homes that I don't see very often today.

We do need to get serious about housing affordability. There are far too many less fortunate fellow citizens with substandard housing, and to our shame, an ever-growing homeless population. I do see some efforts being made at coming to terms with housing for low-income folks, such as the Saskatoon Home Builders who were instrumental in creating the Affordable New Home Development Foundation, and Habitat for Humanity which works to help put people into decent housing. But these efforts are limited by available resources. There is still a lot more that can be done, as anyone who's walked around our cities can see.

It is an indictment of our society that we, in the wealthiest of countries in the world, tolerate an ever-increasing army of unfortunate souls living on the street. The market itself cannot deliver 'affordable' low cost housing for all of the less fortunate that need housing at market rates, and lower taxes alone won't solve the problem. It requires more active and creative intervention – which is where we need government to step in and offer support.

If the home building industry really speaks for the housing consumer, it must speak for all users of housing, and recognize the less fortunate. We need to advocate for a more enlightened approach to housing delivery, including other delivery mechanisms when necessary. It may require other means than just lower taxes.

Richard Kadulski,
Editor

solplan review
the independent journal of energy conservation, building science & construction practice
Editor-Publisher: Richard Kadulski
Illustrations: Terry Lyster
Contributors: Ken Cooper, Anil Pahrek, Herman Rebneris, Rob Dumont, James Reardon, Boualem Ouazia, Janet Ansell
ISSN: 0828-6574
Date of Issue: October 2006
SOLPLAN REVIEW is published 6 times per year by:
the drawing-room graphic services ltd.
PO Box 86627, North Vancouver, BC V7L 4L2
Tel: 604-689-1841 Fax: 604-689-1841
e-mail: solplan@shaw.ca
Street address:
#204 - 1037 West Broadway
Vancouver, BC V6H 1E3
Publications Mail Agreement No. 40013363

Postage paid in Vancouver, BC.
Return undeliverable Canadian addresses to
PO Box 86627, North Vancouver, BC V7L 4L2

SUBSCRIPTIONS: In Canada 1 year $51.94 (incl GST) (NB, NS, NF $55.86 includes HST); 2 years $93.28 (incl GST) (NB, NS, NF $100.32 includes HST). USA and other foreign payable in US $ 1 year $56.00, 2 years $102.00.

CHANGE OF ADDRESS: include a mailing label or copy all information off label for faster, accurate processing.
CONTRIBUTIONS: Unsolicited contributions and manuscripts welcome. Include self-addressed pre-stamped mailer if return requested. Publisher not responsible for loss or damage of same.
While every effort is made to provide accurate and complete information, we do not warrant or guarantee the accuracy and completeness of such information.
ADVERTISING POLICY: Publisher's discretion in the acceptance of any advertisement. No endorsement is stated or implied by the publisher.
PRINTED IN CANADA
GST Registration: R105208805
SOLPLAN is a registered trademark of the Drawing-Room Graphic Services Ltd.

Rain Screen Walls

Richard Kadulski

The design and construction of building envelopes must be based on the assumption that some moisture will accumulate in the wall assembly during construction and during the life of the building.

The rain screen principle was first introduced in 1946 as a rain control strategy. It was further refined in the 1960s, and in 1963 the National Research Council of Canada published the Canadian Building Digest 40 (CBD 40), titled *Rain Penetration and its Control.*

CBD 40 stated that rain penetration of building walls happens all too frequently, despite advances in building technology. Through-wall or complete penetration may damage building contents as well as cause stains and deterioration of interior finishes, and uncontrolled partial penetration, which is less frequently recognized, can permit undesirable quantities of water within the wall. Too much water is a key factor in most cases of building deterioration.

Although traditional wall systems work, it is only recently that scientific studies have been undertaken to explain the mechanisms of rain penetration. Better understanding of these mechanisms makes it possible to design and construct walls from which the problem is virtually eliminated. So while we've known about the importance of better detailing, it is something that we are still coming to grips with. Building codes are only now becoming explicit in their statements about moisture management and how it should be done.

Rain penetration results from a combination of water on a wall, openings that allow water to pass into the assembly, and forces to drive or draw it inwards. Eliminating any one of these conditions can prevent water penetration.

The large number of building envelope failures encountered in coastal BC in the late 1980s to the mid-1990s have changed construction practices, especially for wood frame residential buildings. Although multi-family buildings got all the attention, similar problems have also been found in single-family dwellings. It led to a considerable amount of research, and has influenced building codes. Explicit requirements for moisture management are now incorporated in the code, in particular rain screen detailing for buildings in wet regions.

The face-sealed approach attempts to eliminate all the openings in the wall through which water can pass. The use of a face-sealed approach was a significant contributor to the problems with the west coast building envelope failures.

The materials used to caulk and seal all openings are exposed to extremes of weather, ultraviolet radiation and to movements of the building. Even if the workmanship is perfect, problems of job-site inaccuracies and application conditions, as well as in-service weather stresses will eventually cause the deterioration and failure of these seals, creating openings in the wall through which water can pass. These openings can be extremely tiny and difficult to identify, so that even an extensive maintenance program may not keep the building free of openings. Simply put, history has shown that face sealed building envelopes are not durable in the long term without extensive maintenance.

Staining on backside of siding is an indication of exterior moisture penetration through the siding. This condition is common in most buildings. A rain screen will allow the moisture to dry rather than penetrate further into the wall where capillary forces can keep water contained within the structure so that deterioration can take place.
*Photo from: **Best Practices Guide to Residential Construction: Materials, Finishes, and Details** by Steve Bliss*

The Vancouver Building Bylaw was amended in the mid-1990s to require all buildings larger than a duplex to be built with a rain screen. The 2005 version of the National Building Code of Canada, which is now being implemented into local regulations, explicitly calls for two planes of moisture protection to avoid rainwater penetration problems. The first plane is the cladding (siding, stucco, masonry veneer, etc.), and the second plane is located behind the cladding (i.e. the sheathing membrane). In wet regions, a capillary break must separate the two planes.

In effect, the Building Code now requires a 10 mm rain screen for all buildings in wet climates. Areas that fall into this category include all of coastal B.C. west of the Coast

Mountains, areas around the Great Lakes, Gulf of St. Lawrence, and coastal regions of Atlantic Canada.

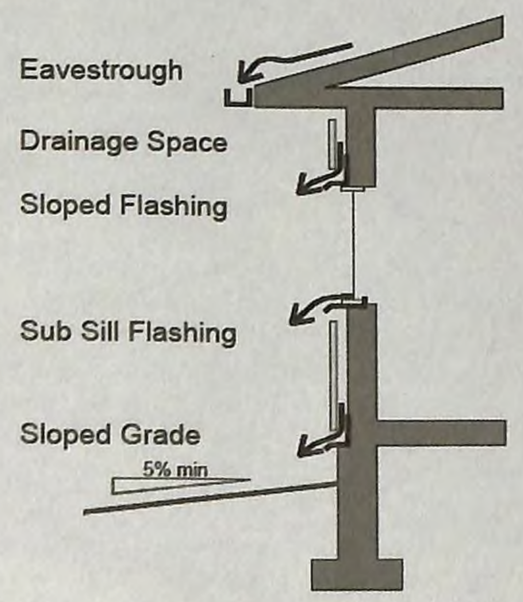
This does not mean that these principles can be ignored in the rest of the country. Exterior moisture management must be carefully considered anywhere a building is built. We've heard about a rash of leaky house problems in Minnesota caused by changes in construction practices that did not adequately account for exterior moisture management. Even in the dry climate of Saskatoon major moisture problems have occurred in buildings because of poor detailing used. ☼

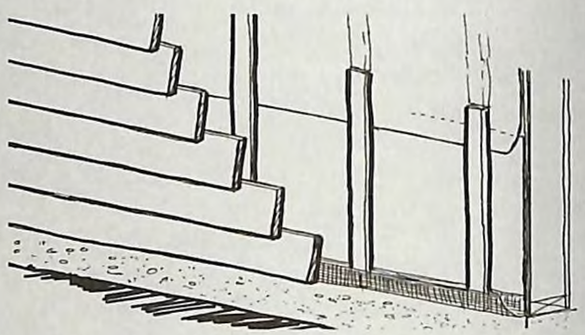
Moisture management of walls: the 4 D's

The principles of moisture management are commonly referred to as the 4 D's of cladding design. These include:

Deflection: using features of the building to limit exposure of the walls to rain, such as overhangs and drips. Rain should be deflected or shed such that wall wetting is minimized. This can be achieved by architectural design – roof overhangs can reduce water falling on the wall by about 50% and buildings can be oriented to limit wind-driven rain exposure. Peaked roofs and overhangs protect a wall from rain by redirecting airflow. Hip roofs provide an opportunity to shelter the walls from rain on all four sides of the building. Landscape design could also provide protection to the envelope from wind-blown rain.

Drainage: using design features that provide a means to direct water that does penetrate the wall back outside. It is important to assume that some rain water will penetrate the outer surface, so the wall assembly should incorporate a drained cavity behind the cladding so that any water that penetrates cladding can freely move out. An air space helps drain the moisture and acts as a capillary break between the cladding and the main wall. The cavity should be at least 6 to 8 mm wide, which is approximately the size of a gap that can be spanned by water. When construction dimensional tolerances are accounted for, a minimum dimension of 10 mm (3/8") is usually used. A wider airspace allows more ventilation airflow which helps dry the cavity.





Drying: using features that facilitate the drying of materials that get wet. Where moisture is absorbed into the wall it must be safely stored until it can dry to the exterior. The drying time should be as short as possible and must not exceed the safe storage time of the materials. The wall design and materials must facilitate diffusion and evaporation of moisture out of an assembly. Drying by diffusion can be in either direction, depending on the materials and the climate. In colder climates the vapour flow is often outwards, and inward drying only occurs during warm weather or when the sun shines on a wall. In hot humid climates water vapour will be driven inward most of the time. Air movement through the cavity (rain screen) can, under appropriate conditions, remove a large quantity of moisture.

Durability: using materials that are tolerant of moisture. The cladding materials and exterior assembly must be durable over the intended service life of the building without excessive maintenance, repair or renewal. ☼

Rain Screen construction

The rain screen wall uses construction techniques to create a vented wall cavity that prevents rain from getting inside the wall. A rain screen incorporates cladding, air cavity, drainage plane and airtight support wall.

Rain screens reduce the forces (air pressure, wind-driven rain and water vapour) that drive moisture into the wall. It's important to realize that rain screen cladding in new homes is justified because they are built differently today. Historically water penetration wasn't a big problem because old houses had building paper and little or no insulation, so walls had open cavities. If moisture got in behind the cladding or siding, there was such a large air space, and so much heat loss that it could dry out relatively quickly. Today, walls are much tighter, and often are finished with low permeability materials so moisture that does penetrate can't get back out.

All rain screens include the following elements:

Vented or porous exterior cladding. Most materials absorb moisture so they must be used in such a way that the moisture can dry out. Applying finishes that reduce moisture absorption (i.e. 'waterproofing' coatings) could inhibit the drying potential for the moisture that does get absorbed or penetrates through the cladding.

Drained cavity. All walls should incorporate a drained cavity behind the cladding. Where water penetrates past the cladding it can be drained to the exterior via flashings or similar means. The sheathing paper on the structure behind the cladding is the effective moisture barrier so it must be installed in a shingled fashion, to allow water to drain out at flashings at horizontal joints or openings. Openings such as windows, doors and grilles must be sealed to the air barrier portion of the wall with projections or overhangs connecting across the rain screen.

The ventilated cladding allows the cladding to dry through the front and the back surfaces, and the wall assembly to dry through the sheathing and building paper into the airspace behind the cladding. Some claddings are inherently self-ventilating such as vinyl and aluminum siding and brick veneers. Other claddings, such as wood siding and stucco have to be installed over spacers to separate the siding from the sheathing in order to vent the siding.

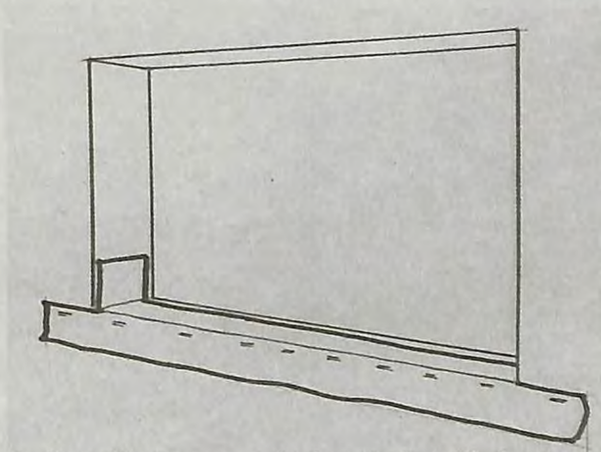
The air cavity must be of sufficient depth to break the surface tension of a water drop, and allow incidental water entering the cavity to drain by gravity and exit with the aid of flashings. The minimum depth identified by the code now is 10 mm (the Vancouver Building Bylaw requires a ¾" (19 mm) cavity).

Rigid, water-resistant, airtight, support walls. The wall assembly must be air-tight, structurally stable enough to resist the wind forces that act on the wall.

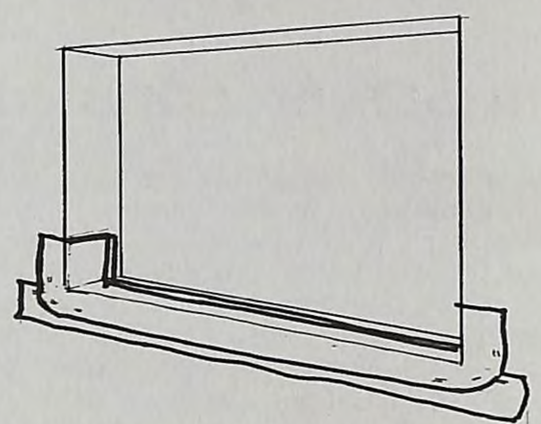
Window Installation Sequence

Windows are perhaps the most vulnerable component in the exterior building envelope. The correct installation can avoid many moisture problems, and enhance the durability of the building. In BC today, it has become standard practice, especially on multi-family buildings for specialist consultants to review in fine detail the design and construction of building envelopes. It is now common to have a window installation mock-up on the site – or at least a photographically documented installation of the first window as a mock-up.

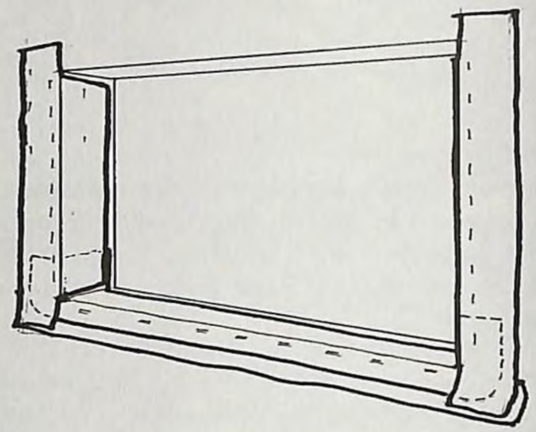
These images present a common approach to good window installation practice – but there are many variations, based on the individuals involved and past experience. The important point to keep in mind are the principles of moisture management.



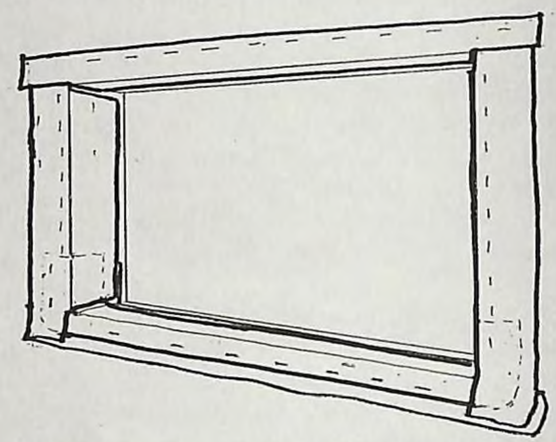
1. Sheathing paper applied to window sill. In some cases, the window sill will be sloped, in others, a metal channel is installed towards to rear of the opening, against which the window frame will sit. The intent is to reduce the possibility of moisture penetration inward. Note that the bottom flap must not be fastened at this time, as the sheathing paper for the house must be able to be slipped in under, to provide shingling of the papers.



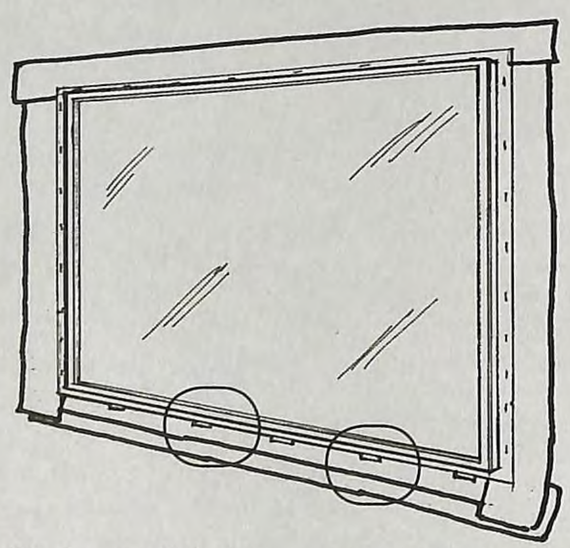
2. *Sub-sill flashing. This image shows Tyvek's Flexwrap, which is a peel and stick type of membrane with a flexible top coat, allowing a single piece to be installed and wrapped around the inner corner. Many builders successfully use a peel and stick membrane, but as that is not as flexible, it requires three pieces to be fitted in each corner, to provide total coverage in the vulnerable corner. In either case, attention must be paid to proper lapping of the membranes.*
Note that these products require the wood and sheathing paper to be primed in order to provide proper adhesion. The peel and stick materials should not be continued more than about 6 inches up the jamb, and not across the window head, as that would introduce an impermeable membrane on the exterior, and could cause other problems.



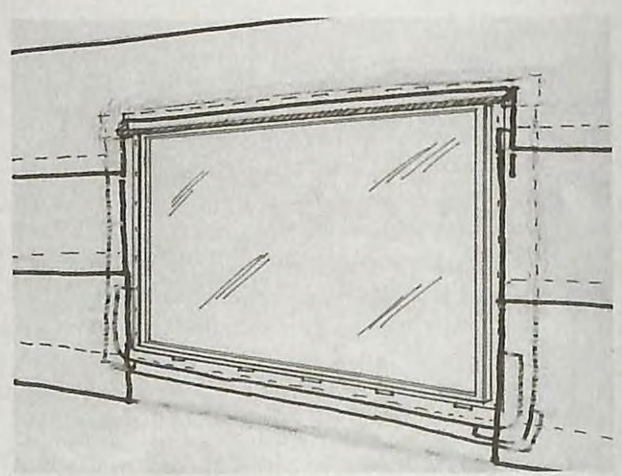
3. *Sheathing paper applied over the jambs. Note lapping of the membrane.*



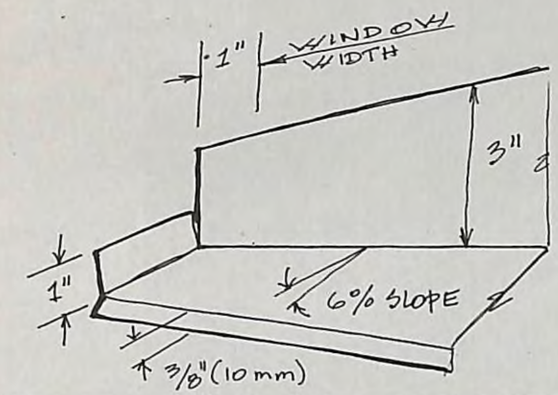
4. *Sheathing paper over the window head.*



5. *Window installed. It is common to apply a caulking bead under the window nailing flange, along the jamb and window head. There should never be any caulking under flange at the windowsill, since that area need to be drained. Wedges under the sill flange keep a drainage channel open.*



6. *Head flashing is installed over the window, and sheathing paper installed over the rest of the wall. Note that the sheathing paper must lap over the flashing and all laps of the paper.*



Typical window head flashings.
The latest edition of the National Building code has revised flashing requirements. Key changes include: flashing must extend past the window; there must be an end dam (the end of the flashing needs to be turned up by one inch), the flashing upstand must be at least 3 inches high (higher in locations with considerable wind driven rain); the flashing must slope outward at least 6% (after allowing for any shrinkage that might affect the flashing), and the projecting drip must be at least 3/8".

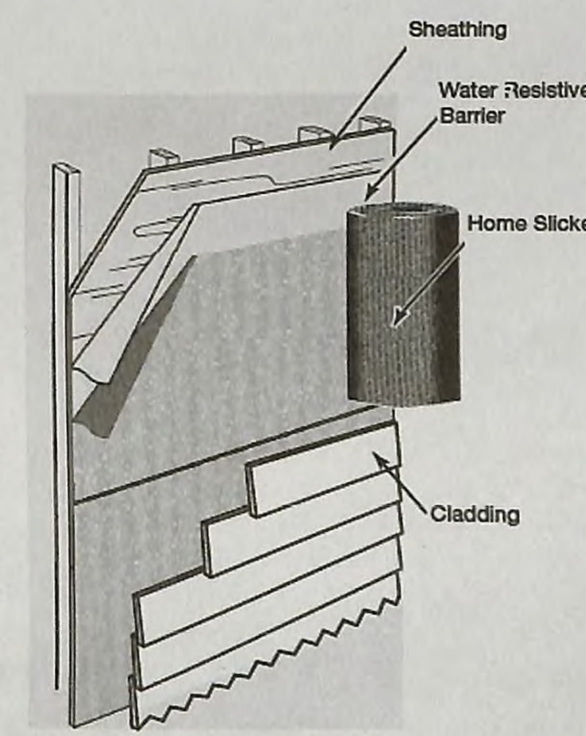
Proprietary Rain Screen Products

A rain screen can be assembled in a number of ways. Some manufacturers are developing drain mats that offer alternatives to wood strapping.

Delta®-Dry is a water resistive barrier and drainage membrane formed from a silver-colored 0.55 mm thick high density polyethylene into a studded sheet with an overall thickness of about 7.5 mm. The "studs" are located 41 mm on center, in rows half that distance apart and provide drainage spaces on both sides of the sheet.

Delta®-Dry is intended to replace the building paper or housewrap in a conventional wall design. It is impermeable to water so any water getting past the exterior cladding, through leakage or solar driven vapour drive is prevented from penetrating any further into the wall assembly, but it still allows drying of interior moisture to the exterior because of the air gap on the studded side of the membrane. The contoured design provides drainage channels for any such water to be directed by gravity to the bottom of the wall and out of the assembly.
Cosella-Dörken Products, Inc.
www.cosella-dorken.com

Home Slicker



Home Slicker is a ventilating and self-draining rain screen that provides a vertically channeled air and drainage space. This rain screen allows bulk moisture that penetrates the siding (from driven rain or capillary movement) to drain away. It is a three-dimensional nylon matrix that is rolled out onto the wall over the housewrap or building paper with the siding applied over it. Home Slicker can protect and lower moisture levels in various siding systems, but is especially effective for wood lap siding, wood shingles or shakes, fiber cement, and EIFS (exterior insulation and finish systems). Each roll is 39 inches wide. It is flexible, lightweight and is easily installed by stapling or tacking every three square feet.

When Home Slicker is used with stucco, the Typar should face outward (toward the stucco) to prevent the mat from being filled with cement and to keep a clear drainage path for incidental moisture that may find its way behind the stucco.
Home Slicker manufactured by Benjamin Obdyke
http://homeslicker.com

When Things Go Wrong

Herman Rebneris, a Victoria builder, sent these photos of a house he observed under construction. The builder of this house not only shows poor construction quality, but also a lack of understanding of proper workmanship. Sadly, the builder is a licensed builder who obviously does not understand the building science required to properly supervise his exterior envelope trade, which has no training requirements.

Currently, a building envelope technician training program is being developed in BC. In the case of multi-family projects, municipalities and the warranty companies insist that a building envelope consultant do the design and provide site inspections of the work. No such requirement exists for single-family construction except in some cases of a more elaborate design or unusual site conditions where the municipal inspector may require a third party review. In most cases, normal inspections do not include the exterior envelope before covering over with siding or other materials.

Rebneris suggests that because the exterior envelope is such an important part of the building, the building envelope trade should be in the same category as an electrician and a plumber and become a "mandatory" trade. As much as we want fewer regulations, perhaps we should have more good regulations. As we keep moving into busier times, with labour shortages and more skilled workers retiring, we are increasingly seeing a larger, less skilled work force that too often does not have the time to get proper training. ☼

No moisture deflection membranes installed prior to installation of the window.

Reverse laps on the sheathing paper. Any moisture that penetrates past the siding will be directed behind the building paper.

Incorrect layering of sheathing paper.

Window Energy Ratings Changed

The CSA window standard includes a portion that deals with energy performance of windows (CSA A440.2). The intent of the standard is to offer a tool to allow window users to compare alternative glazing products on an equivalent basis. This is not unlike the vehicle fuel ratings or appliance energy consumption ratings to which we have become accustomed . The energy consumption numbers may not completely reflect real world operating conditions, but they serve a useful purpose.

Recently, the CSA A440.2 (Energy Performance of Fenestration Systems Standard) was changed. The most significant change was a revised procedure for calculating the energy rating (ER). Unfortunately, they forgot to let prospective users know about the changes. Perhaps it is a quiet acknowledgement that the ratings aren't being used much, at least by consumers, as marketing shifts to Energy Star labels.

The ER format was changed so that numbers are mostly positive dimensionless numbers. The older format (which had units (W/m^2) had a mixture of negative and positive numbers and were a direct reflection that in most cases windows are a source of heat loss, which explained why most numbers were negative. That added confusion for consumers. The new system results in almost all numbers being positive, and the larger the number, the better the window.

Among a number of changes in the revised standard, published in the beginning of 2006, are:

☞ Harmonizing the Canadian test and rating procedures with US methods developed and implemented by the NFRC (National Fenestration Rating Council). These harmonization aspects affected:

- The standard size of windows used for testing and rating
- Use of ISO 14099 methods for determining the U-value (window heat loss coefficient),
- SHGC (solar heat gain coefficient) and other parameters
- Definition of certain types of windows

☞ Introducing an allowance for the effects of interior window covering (blinds and other furnishings) in solar gains calculations for the Energy Rating procedure.

Comparison of Energy Ratings of Generic Window Types *(old and new standard)*

Generic Type of Windows	CSA A440.2 1998 (old standard)	CSA A440.2 2004 (New standard)
Operable windows or fixed glazing with a sash		
Double glazed, low-E *(0.2 or better), 13 mm air space, sealed unit, metal spacer, and thermally broken metal frame*	-17	15
Double glazed, low-E *(0.2 or better), 13 mm argon-filled sealed unit, metal spacer, and wood or vinyl frame*	-10	23
Double, low-E *(0.2 or better), 13 mm argon filled sealed unit, insulated spacer, wood, vinyl or fiberglass frame*	-12	21
Fixed glazing without a sash		
Double, low-E *(0.1 or better), 13 mm argon filled sealed unit, insulated spacer, wood, vinyl or fiberglass frame*	-11	22
Double, low-E *(0.1 or better), 13 mm argon filled sealed unit, metal spacer, wood, vinyl or fiberglass frame*	-1	32
Double, low-E *(0.1 or better), 13 mm argon filled sealed unit, insulated spacer, wood, vinyl or fiberglass frame*	1	34
Natural Resources Canada's ENERGY STAR for windows website includes a database of more than 21000 qualified products. [Go to *energystar.gc.ca* and follow the links to qualified products, windows and list of qualified products.]		

The above changes affect the original ER ratings of CSA A440.2-1998 by about 6 points.

In addition, in the new procedure a constant value of 40 W/m^2 was added as an adjustment to the ER for all window types. Thus, in the new adjusted ER list, the better the window the bigger its number. So, for equivalent windows technologies (low-e, inert gas filling, insulated spacer, composite frames and so on), irrespective of type of operator (picture, casement, awning, sliders, hung and so on), the newly defined ER will show fairly similar ratings. An approximate conversion to the new format can be made by adding 33 to the old numbers. Typical old and new ER numbers are shown in the table.

Energy Rating

The Energy Rating (ER) value is calculated using a formula that balances a product's U-value (U= 1/R) with its potential solar heat gain coefficient (SHGC) and airtightness. The following tables show the levels for each zone in Canada - the country has been divided into 4 zones. The climate zones for which a window, door or skylight is ENERGY STAR qualified will be shown on a label or on its sales literature. Zone A applies to the mildest climates in southwestern BC, and zone D covers the coldest regions in northern Canada. The ratings given in the tables are for the entire product. Energy efficiency ratings for the glass portion only, often called "centre-of-glass" ratings, usually make the product appear more energy efficient than it really is.

The minimum ENERGY STAR Requirements for Windows and Doors are listed in the following table. (Products may comply based on either their U-value and R-Value or their Energy Rating.)

Minimum ENERGY STAR Requirements for Windows and Doors

Zone	Maximum U-values and Minimum R-Values				Minimum Energy Rating (ER) Values (Maximum U-value 2.00 W/m²•K)			
	U-value (W/m²•K)	U-value (Btuh•ft²•°F)	R-Value (ft²•h•°FBtu)		(Most Windows and All Doors)		(Picture Windows Only)	
					1998	2004*	1998	2004*
A	2.00	0.35	2.9	or	-16	17	-6	27
B	1.80	0.32	3.2	or	-12	21	-2	31
C	1.60	0.28	3.6	or	-8	25	+2	35
D	1.40	0.25	4.0	or	-5	29	+5	39

Zones for Canadian Energy Star window standard

Canadian Energy Standards

Ken Cooper

The energy efficiency of new housing has improved significantly over the years. Some housing surveys have shown that recently built new housing is, on average, 13% better in overall energy efficiency (mainly space heating and hot water usage) than the housing built about 15 years ago. Improvements in the energy efficiency requirements in building codes is a key factor in the overall reduction of energy use associated with housing and also with the reduction in the generation of greenhouse gases.

A survey of residential energy codes across Canada found that explicit requirements for energy efficiency exist only in B.C., Manitoba, Ontario and Quebec. The rest of the country uses the National Building Code which has no significant energy-related requirements.

Residential Energy Code Requirements

Air-tightness is less regulated by the building codes. Although the building code has air and vapour barrier requirements, the overall air-tightness is not tested. Manitoba requires an NLA (normalized leakage area--a measure of air-tightness) of 2.0 cm²/m² envelope area or less – a level that is met by more than 85% of new surveyed houses.

To put the survey data in perspective, the study evaluated more than 4,300 new single-detached houses built between 2000 and 2005 across Canada, using data from the Energuide for Houses (EGH) database. House area, volume, airtightness and construction characteristics were reviewed to create a set of archetypes for eight geographic areas, according to the availability of data. These Energuide walk-through evaluations provided some interesting insights into tract-built housing being built today:

Envelope Minimum Requirements (nominal unless stated otherwise)																Air tightness	
			Ceiling		Main	Exposed	Windows		Basement		Crawlspace	Slab on grade					
			Attic	Joist	walls	Floors	R-value	ER***	walls	depth bg	walls	heated		unheated			NLA
Zone			R-value	R-value	R-value	R-value	or type	fixed/oper.	R-value	ft	R-value	R-value	area	R-value	area	ac/h_{50Pa}	cm/m²
BC	<=3500DD	gas	40	28	14	28	double		12	2	14	12	full	10	2 ft	vapor & air barrier	
		electric/oil	40	28	20	28	double		12	2	20	12	full	10	2 ft	systems (no tested	
	<4500DD	all	40	28	20	28	double		12	2	20	12	full	10	2 ft	requirement)	
	>=4500DD	all	44	28	22	28	double		12	2	20	12	full	12	2 ft		
AB	A	National Building Code of Canada*															
	B	National Building Code of Canada*															
SK		National Building Code of Canada*															
MB	<53° Lat.	gas	40	28	20	32			12	2		5	full	5	3.3 ft		2.0
		electric/oil	40	28	20	32			20	2		5	full	5	3.3 ft		2.0
	>=53° Lat	all	50	28	26	32			24	2		5	full	5	3.3 ft		2.0
ON	1	gas/oil	40	28	20	25	2.84		12	2		10	2 ft	8	2 ft		
	(<5000 DD)	electric	50	28	30	25	2.84	0/-13	20	2		10	2 ft	8	2 ft		
	2	gas/oil	40	28	20	25	2.84		12	2		10	2 ft	8	2 ft		
	(>=5000 DD)	electric	50	28	30	25	2.84	0/-13	20	2		10	2 ft	8	2 ft		
QU	A	all**	30	30	19	27	2.84		12	full height	12						
	B	all**	32	32	20	27	2.84		12	full height	12						
	C	all**	34	34	22	27	2.84		12	full height	12						
	D	all**	36	36	23	27	2.84		12	full height	12						
	E	all**	39	39	24	27	2.84		12	full height	12						
	F	all**	40	40	26	27	2.84		12	full height	12						
NB	all	National Building Code of Canada*															
NS	all	National Building Code of Canada*															
PEI	all	National Building Code of Canada*															
NF	all	National Building Code of Canada*															
YT	all	National Building Code of Canada*															
NWT	all	National Building Code of Canada*															
NU	all	National Building Code of Canada*															

Insulation levels are nominal R-values, not effective values for assemblies.
* National Building Code of Canada has no specific insulation requirements except that insulation be used to prevent condensation.
The National building code does recommend using the Model National Energy Code for Houses (MNECH).
Provinces using the National Building Code usually impose some, non energy related, modifications
** Quebec: Total assembly R-value requirements between framing members
*** ER ratings are the 'old' rating values (CSA A440.2-1998)

- In Quebec and the Maritimes about 90% of new houses comply with the ventilation system requirements of the National Building Code, while compliance in the rest of Canada is much less (typically 20% to 60%).
- Heat recovery ventilation system use is predominant in the Atlantic provinces, where about 93% houses have HRV systems installed. On the other hand, in BC barely 2% of new houses have a dedicated heat recovery system.
- For the provinces in which natural gas is the primary space heating fuel (Ontario and west), either direct-vent (Saskatchewan, Alberta and BC) or condensing furnaces (Ontario and Manitoba) constitute the majority of installed systems. Condensing gas furnaces are installed in 94% of new Ontario houses, but only 5% of new Alberta houses. In Quebec and the Maritimes, baseboard electric is the dominant heating system. In the Territories flame retention head oil systems predominate.
- Airtightness – EGH surveyed values range from 1.9 ac/h at 50 Pa depressurization for Manitoba (Saskatchewan and Quebec are close behind), to 3.4 in Ontario and the Maritimes, to 4.3 ac/h for BC and the Territories (Alberta slightly better).
- Insulation levels – walls are typically 2x6 R-20 or equivalent (Ontario typically uses EPS clad 2x4 walls), except in BC's Lower Mainland where in gas heated houses R-14 2x4 walls predominate. Attics are typically R-40, except in Ontario and Quebec where the minimum requirement is slightly less. Basements are often insulated to R-12, although not always for the full height (Ontario requires only R-8 for the first 2' below grade, although full height insulation is being introduced in coming code changes).

The National Building Code requires double glazed windows (NBC Sec. 9.6.6.6. and 9.6.7.2). Electrically heated houses in Ontario require Energy ratings of 0 and –13 for fixed and operable windows, respectively[1]. Quebec requires a minimum RSI of 0.35 – slightly higher than a standard vinyl framed slider.

In BC the building code insulation standards

[1] Double glazed sliding windows with thermally broken frames have an ER of –25. A double glazed, hard coat low-E with Argon fill and metal spacer, vinyl framed slider has an ER of –12 and would meet the Ontario code requirement for electrically heated housing. [note, these ER ratings are the 'old' ratings, based on the original CSA A440.2-1998 calculation approach, not the recently revised standard].

Ventilation Systems in New Houses

	Fuel	Code required	Number Houses	Fans	HRV	none	Remarks*
B.C.	All	BCBC	252	20%	2%	77%	Most zone A
Alberta	All	NBC	1418	58%	4%	38%	Most zone 1
Saskatchewan	All	NBC	209	9%	38%	53%	
Manitoba	All	NBC	114	4%	25%	70%	Most zone 1
Ontario	All	OBC	847	5%	24%	71%	Most zone 1
Quebec	All	NBC	1106	6%	84%	10%	Regions A & B
Maritimes	All	NBC	389	1%	93%	6%	All Maritimes
Territories	All	NBC	154	11%	9%	80%	All Territories

source: EGH database, houses built post 1999
* Regions defined by the Model National Energu Code for Houses

code insulation standards are not being changed at this time, although provincial energy efficiency regulations have been changed. Gas and propane fireplaces will have to be tested and labelled effective January 1, 2007.

Anecdotal surveys indicate that high performance windows (typically double glazed, low E coated, Argon filled) are commonly used in Saskatchewan, Manitoba, the Maritimes and Territories and are beginning to make inroads in the rest of Canada. Some utilities are introducing incentives for the use of high performance windows. Since windows can account for 25-50% of the heat loss of a house (depending on house design, climate and window types) any improvement of window performance will have a significant impact on the home's energy use, not to mention comfort.

Based on the EGH evaluations, the average new gas-heated house in BC has a total energy use only slightly less than code minimum houses, suggesting that many BC houses do not meet minimum code requirements.

The average new, gas-heated houses in zone 1 of Manitoba, Ontario and Quebec used 88% to 93% as much energy as the code minimum houses. Houses in zone 2 of Quebec (surrounding Quebec City) were much better insulated and airtight – using less than 83% as much total energy as the code minimum house.

If R-2000 levels of energy efficiency were applied (equivalent to an Energuide 80 rating), the space heating energy use would be reduced by about 20% in Quebec (zone 2) to 55% (BC zone A). Based on surveys of more than 800 new conventional and recently built R-2000 houses, implementing a construction standard equivalent to Energuide 80, the total average energy consumption would be reduced by about 36%.

Upcoming...

Ontario has recently introduced substantial changes to the Ontario Building Code. The insulation requirements are being phased in. The values shown in the table are those effective December 31, 2008. In addition to building envelope insulation levels, the Ontario code will require that natural gas and propane fired furnaces be at least 90% efficient (AFUE).

The Ontario Building Code also requires that as of January 1, 2012, all new houses will have to be built to a standard that would at least meet an EnerGuide 80 rating.

In BC the building code insulation standards are not being changed at this time, although provincial energy efficiency regulations have been changed. Gas and propane fireplaces will have to be tested and labelled effective January 1, 2007. Gas and propane furnaces will have to be condensing gas furnaces (90% AFUE) by January 1, 2008. Windows will have to have a USI value less than 2.0 W/m2K by January 1, 2009. [U = 1/R, so this is equivalent to an R-value of 2.85]. ☼

Ken Cooper, of SAR engineering ltd., is a building analyst, working primarily in the fields of residential monitoring and simulation since 1976.

Technical Research Committee News

Treated Wood Caution

We've reported on the changed formulations being used to treat wood. ACQ, which is now the principal form of treatment of lumber used in residential construction, has particularly corrosive properties, largely due to the carriers that are used for the preservative chemicals. The issue appears to be that the standards that apply to wood treatment do not apply to the chemical formulations, and as the treatment industry has many players, there is still much fine tuning of the treatment processes and formulations with the new preservatives, so there may be considerable variation between treatment plants and even between batches of treated lumber.

Corrosion of galvanized fasteners can occur in a very short time. Builders in the Vancouver area have noted corrosion on double galvanized fasteners happening within months of installation. There has been a report of a deck collapse in Calgary while it was occupied and a barbeque was in use. (Fortunately, there were no major injuries nor fire).

That is why stainless steel fasteners have been recognized as the best material to use at this time that can offer any reliability in application.

Perhaps it's time for builders to review just how much treated wood is being used, and whether its use is justified. We've observed many applications where treated wood is used in exterior applications where it is not necessary. Often there are alternate details that will offer serviceable and durable applications without the need for treated wood.

Basement construction

Basements serve as the foundation supporting the house structure, and increasingly are used as livable space. However, basement failures are the major source of warranty complaints in new houses. New home warranty programs across Canada report that the combined action of water and soils on basements is responsible for most major basement failures in new homes.

A survey of warranty claims in 1994-1995 showed that frost action on basement walls was a contributing factor in 40% of the failures; swelling clays (resulting from strong fluctuations of wetting and drying in clay soils) were responsible for another 36%; and frost action on the footings, a high water table and the presence of water-borne soluble salts contributed another 9%, for a combined total of 85% of all failure cases surveyed. The survey by the National Research Council (Institute for Research in Construction) led to a basement research project, which led to the publication of the *Performance Guidelines for Basement Envelope Systems and Materials*.

Since basements are increasingly used as living space, we need to pay more attention to how they are built as the space has to match the same high environmental conditions we expect in above ground buildings. The basement guidelines are meant to help with the design and construction of cost-effective basement systems that will achieve satisfactory performance in a cold climate such as Canada's.

The Basement Guidelines emphasizes that the National Building Code of Canada and its provincial counterparts are documents setting out minimum requirements, so they can't anticipate all of the variations in conditions under which a basement is expected to perform. Thus regionally site-sensitive appropriate designs have to be made by the designer/builder. In order to achieve successful basements, builders' experience, local builders' guides and standards have to be considered. The guidelines are intended to provide a tool to help review basement details and materials, in order to provide better basement details.

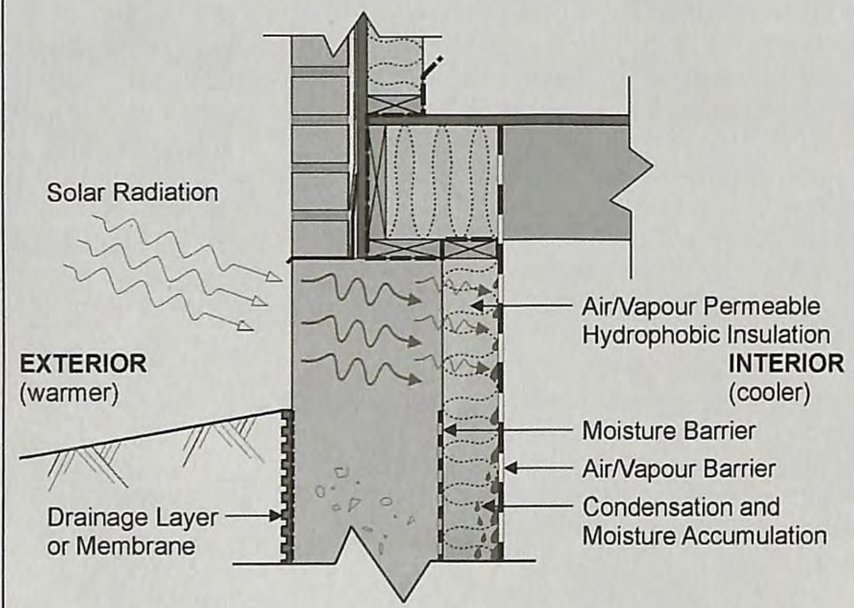
There are many different ways to build a basement. In basements built with new materials, higher insulation levels must be detailed keeping in mind that the basement is a system, so that air, thermal and moisture flows have to be considered carefully if the construction is to function as intended. At the same time, a balance has to be kept between first cost, cost of repair (including warranty work), and cost of maintenance and operation.

It may be more profitable to build basements intended to be living spaces (Class A basements) from the outset because the use of an explicit drainage layer reduces the cost of callbacks and helps maintain an established reputation. However, structural integrity and moisture and thermal protection measures must be systematically dealt with to achieve acceptable levels of performance.

Canadian Home Builders' Association

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

Canadian Home Builders' Association, Suite 500, 150 Laurier Ave. West, Ottawa, Ont. K1P 5J4
Tel: (613) 230-3060
Fax: (613) 232-8214
e-mail: chba@chba.ca
www.chba.ca



The dominant temperature gradient during summer months drives moisture entrained in the foundation wall inward, where it condenses on the outboard face of the air/vapour barrier. Much of the insulation and strapping normally reach saturation, and in some cases, bulk water runs out the bottom of the interior finished wall assembly (often mistaken for leakage).

*Typical detail found in **Performance Guidelines for Basement Envelope Systems and Materials: Final Research Report**.*

For the consumer, basement upgrades represent high marginal benefits because, for a relatively small incremental premium, additional livable space is provided cost effectively. In addition, properly built and insulated basements provide improved comfort and lower energy bills.

The cost effectiveness of basement system alternatives must be premised on well-performing systems, which are warm, dry and free from mould and other contaminants. Meaningful comparisons may only be carried out after having satisfied these basic performance requirements.

The basement guidelines document is comprehensive and covers all aspects of basement design and construction. Although the document is thorough (193 pages) and readable, a word of caution is needed, as the document remains somewhat academic in tone.

Performance Guidelines for Basement Envelope Systems and Materials: Final Research Report. Copies can be downloaded from the IRC web site:

http://irc.nrc-cnrc.gc.ca/pubs/rr/rr199/index_e.html

Garage Fan Interconnect

Garages are a major source of contaminants. Although the assemblies between the garage and the house are supposed to be gas tight, tests have shown that there is a considerable amount of gas leakage, and there have been many documented cases of garage CO entering the house. Because of the way that CO detectors work, with a time-weighted average calculation of CO concentrations before the alarm is triggered, the connection between the garage as the source of CO is not always made.

One solution that is being explored is the installation of automatic exhaust fans in the garage, to help purge fumes from the garage. One manufacturer has now developed a prototype product that interconnects a garage exhaust fan with a CO detector and the door opener to deal with car emissions. They are looking for builders interested in testing the unit. Any builder willing to try the equipment should contact Don Johnston at CHBA in Ottawa.

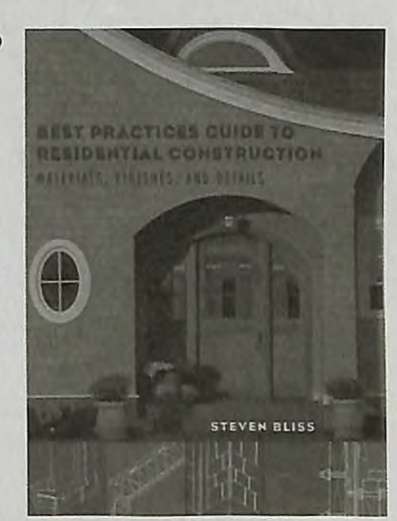
Best Practices Guide to Residential Construction: Materials, Finishes, and Details

We are using a multitude of new materials today. Our understanding of building performance has improved, and we know more about how little we know than ever before. The frontline of practical information to help builders and designers to deal with these changes are the magazines we all see. Some are better than others.

Steve Bliss was an editor at the Journal of Light Construction, one of the most practical and useful builder publications, for more than two decades. A successful formula used by that publication is to search for feedback from people working in the field. The result is that they are able to provide practical, well-illustrated information.

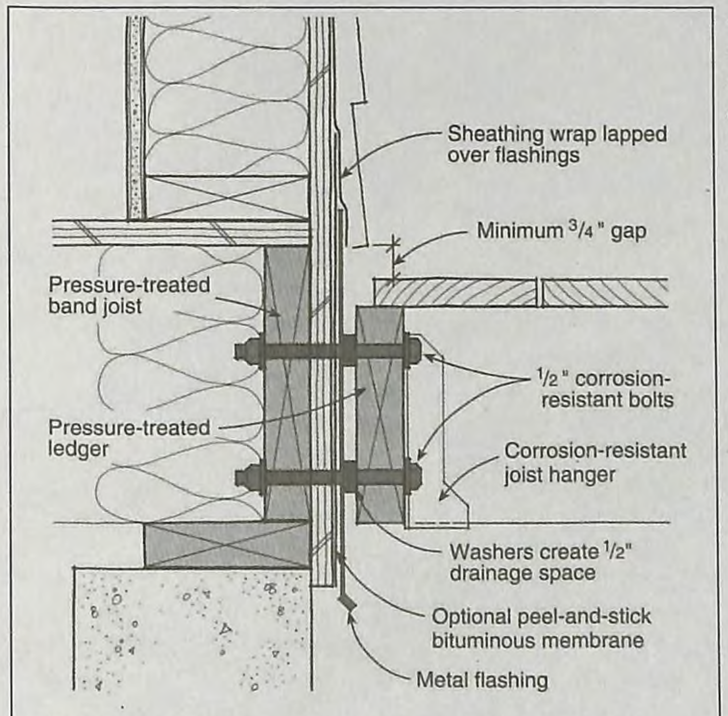
However, when we need to refer to something, it's usually a challenge to find that information in the stack of past issues in the corner of the office – which is why books, with their compact format, indexes and portability are still an essential part of our toolbox. When was the last time you could fire up the computer on the job site to look up how to deal with a problem?

The same approach used in the Journal was applied to *Best Practices Guide to Residential Construction: Materials, Finishes and Details* which offers a practical guide to product and material selection to make informed purchasing decisions about major building components, and highlights critical installation requirements. This is a very well illustrated book that provides up-to-date recommendations based on actual field performance, providing a readable, real-world perspective.



Although some references are based on US practices and standards, there is still a lot of valuable information for Canadian builders. Since many manufacturers sell their wares in both countries, the source references will also be useful.

This is a book well worth reviewing.



Spacing the ledger away from the house helps prevent decay in the sheathing and band joist if the area gets wet, but this requires more bolts. A bituminous membrane across the band-joist area offers an extra layer of protection, useful in very wet or snowy regions.

Best Practices Guide to Residential Construction: Materials, Finishes, and Details
By Steve Bliss
John Wiley & Sons Inc.
ISBN: 0-471-64836-1

Energy Answers

Rob Dumont

I read your column with great interest and would like to get some specific feed back.

In April 2006 I completed a new 3500 sq. ft 1½ storey home with a finished basement in St. Albert, AB. The home has a bonus room over the garage that is 4 risers lower than the second floor level. I have previously owned an R-2000 home and was very dissatisfied with the noise and performance of the HRV (air-to-air heat exchanger).

The house has R-20 walls, R-50 ceilings, R-8 windows, R-20 in the basement walls and R-5 under the basement slab. I installed a 92% efficient Trane furnace and a 91% AFUE NTI boiler with boilermate system. The site is well treed with 50 ft trees and we are comfortable without central air conditioning. The hydronic system supplies floor heat to the basement, ensuite, entry foyer, kitchen nook, the 600 sq ft bonus room over the garage, the rear portion of the second floor and the garage floor. We have a high output "Bis Panorama" wood-burning fireplace with a high return air grille in the great room. The furnace circulates forced warm air to all rooms on all floors.

The in-floor heating is set to a comfortable temperature in each of the hydronically heated rooms and the DC furnace fan is on "run". The thermostat on the furnace is set around 15°C. We find we have the most wonderful fresh air in the house and it is draft free and comfortable. I heat the garage slab only enough to keep everything from freezing. We tend to open windows whenever the weather allows.

Our energy costs seem moderate for the size of house when it was under construction, but we haven't lived in it for a winter yet. Can we get enough fresh air if we only run the furnace fan 10 minutes per hour with an Air Cycler? Can we lower heating costs by not heating the basement slab (or to a low temperature, say 15°C) if we are not using the basement? Anything else you can recommend to lower heating costs?

WK, St. Albert, Alberta

Every house needs ventilation. Most older houses get their ventilation from air leakage, but most modern houses on the Canadian prairies are now tight enough that a mechanical ventilation system is needed.

Why do houses need ventilation? Let's go back to the fundamentals. There are five main reasons.

First, people need about 8 Litres per second (15 cubic feet per minute) of reasonably clean air for health and comfort. We ingest air with about 380 parts per million of CO_2 (the outdoor CO_2 level) and our lungs reject carbon dioxide into the air that we exhale. The air exhaled in our breath is loaded with carbon dioxide – it has about 40,000 parts per million or 4% CO_2. If you recycled that exhaled breath directly back into your lungs, you would soon be overcome with carbon dioxide poisoning. This is essentially what happened in the Black Hole of Calcutta, when a large number of people died in a confined space. My dad, who was an anaesthetist, told me that controlling carbon dioxide in operating room patients is a key concern, because anaesthetic gases are expensive and are recycled back into the patient. The carbon dioxide laden air is put through a scrubber to remove this gas. On submarines and spacecraft, scrubbers are also used to minimize the amount of expensive fresh air. Inside houses and most buildings, carbon dioxide levels should generally be below about 1000 parts per million. If the level is higher, it is usually a sign of inadequate ventilation (or a blocked chimney.)

A second reason that humans must have ventilation is to get rid of moisture that the body emits. Sedentary adults release about 0.1 kilogram (0.1 litres) of moisture per hour, partly through breathing and partly through skin evaporation. Cooking, bathing, floor washing, etc. all contribute additional moisture to the air. One of the common signs of inadequate ventilation in a home is high humidity, with condensation on the windows.

A third reason for ventilation is to dilute body odour, perfumes, deodorants, cologne, etc.

A fourth reason to ventilate is to remove the offgassing from building materials. The paints, floor coverings, furniture, cabinets and so on all will all emit some volatile organic compounds, and these should be diluted by adequate ventilation. It is also important to choose building materials carefully to avoid organic compound emissions and formaldehyde.

A fifth reason to ventilate is to ensure that there is adequate combustion air for furnaces, boilers, water heaters, fireplaces, etc. When any fuel burns, sufficient air must be supplied or deadly carbon monoxide can readily occur.

In older houses, leaky walls and ceilings will generally provide enough ventilation air through most of the year. However, when there is no wind and the temperature inside the house is the same as outdoors, there is no driving force for ventilation, and very little air change will result. I can remember my grandparents' home in Vancouver and the times during the warmer months when there was a distinct 'old house' smell to it.

For all the above reasons, I am a strong advocate of continuous mechanical ventilation –24/7/365.

Getting back to your specific concerns, I infer that in your house you have a fresh air duct that goes into the return air plenum of the furnace, and that this provides ventilation air because you run the furnace fan continuously. There is no heat recovery with that system, and you do pay an energy penalty for heating the air passing through your house. If you only ran the furnace fan 10 minutes an hour, you likely would get a reduced amount of ventilation and possible air quality problems.

Short of measuring the amount of air coming into your house, I can't quantify how expensive the annual heating bill for the ventilation air is. If the flow is 75 cubic feet per minute (35 Litres/second), I would estimate the annual cost of heating the ventilation air at about $200 a year if you are heating with natural gas.

As to your second question about turning off or reducing the basement radiant floor heat to save money, I would recommend that you try it. With an insulated floor, the heat losses through the floor are modest. I estimate that a basement floor with R5 (RSI 0.88) insulation will lose only about 2 BTU/hour per square foot of floor area, or about 3500 BTU/hour for a 1750 square foot basement, but this could vary depending on the moisture content in the soil. Heat losses from the furnace ductwork are often enough to offset the basement heat losses. As you are already circulating air from the furnace to all rooms, the floor heat will likely be superfluous.

Another low cost way to save energy in most houses is to use a timer thermostat. For every one °C that you lower the average house temperature in Edmonton's climate, you can save about 3% on your heating bill. ☼

Fresh Air?

It's hard to avoid being bombarded by commercial messages selling 'air fresheners'. The manufacturers are flogging their products everywhere. Walk through any supermarket or hardware store and you'll be confronted with a whole row of smelly stuff. The manufacturers claim that if you buy their products, you'll be providing a fresher indoor environment. There is nothing further from the truth. What they are really doing is selling chemicals to mask other odours.

Studies at the US National Institute of Environmental Health Sciences have found that chemicals used in many 'air fresheners' (e.g. air fresheners, toilet bowl cleaners, mothballs and other deodorizing products) may be harmful to the lungs of people who inhale the stuff regularly. Because people spend so much time indoors where these products are used, it's important to realize that even exposure to low levels of the products can have an impact on the respiratory system. To date there has been very little research on the health effects of these compounds in non-occupational settings.

The best way to protect yourself, and especially children who may have asthma or other respiratory illnesses, is to never use these products. It is best to install an effective ventilation system and ensure that it is operating constantly. Even in older houses, a good quality exhaust fan, properly installed and allowed to run for prolonged periods (for example 20 minutes each 60) can help improve the indoor air quality. ☼

NRC·CNRC

Hybrid Ventilation Research for Houses

by James Reardon and Boualem Ouazia

Buildings represent 30% of total energy consumption in Canada. In thermally well-insulated buildings, ventilation and air conditioning may account for more than 50% of the energy consumption. Improvements in the energy efficiency of ventilating buildings can therefore make a real impact toward reducing Canada's overall energy consumption and greenhouse gas (GHG) emissions.

Ventilation provides air for occupants and removes indoor air pollutants generated from indoor sources, e.g., carbon dioxide and water vapour from occupant activities, and volatile organic compounds (VOCs) from modern furnishings and consumer products. Natural ventilation, through openings in the building envelope, is driven by natural forces: wind and temperature differences between indoors and outdoors, not requiring fans powered by electricity. Those natural driving forces vary with weather, and so may not be reliable, causing too little or too much fresh air exchange. Discomfort due to cold drafts, uncontrolled air distribution, and impractical heat recovery or filtration are some of the other disadvantages.

Mechanical ventilation, on the other hand, is easily controlled, lends itself to straightforward application of heat recovery and filtration, and is reliable. However, it consumes electrical energy and thereby causes GHG emissions. As modern construction trends are creating Canadian houses that are more and more airtight, concerns about inadequate natural ventilation have led to increasing requirements for mechanical ventilation in Canadian building codes. NRC-IRC is conducting a research project, one part of which is an examination of the natural ventilation rates typical in existing Canadian houses.

Hybrid ventilation strategies, combining the advantages of both natural and mechanical ventilation strategies and using each to offset the disadvantages of the other, may offer an approach to reduce the energy required to provide necessary ventilation in Canadian buildings. Houses and other small buildings covered under Part 9 of the National Building Code are a logical place to start developing these strategies.

With a good design, a hybrid strategy should be able to minimize the excess energy consumed from overventilation and avoid the indoor air quality problems associated with underventilation. Intelligent control systems that automatically switch between the natural and mechanical ventilation modes, modulate fan speeds and vent openings to ensure a steady ventilation rate and adequate interior distribution of the supply air should be able to minimize energy consumption and maintain a satisfactory indoor environment.

The objective of this research is to develop innovative energy efficient hybrid ventilation strategies for single-family residential buildings and to evaluate their performance for reliable standards compliance, indoor air quality, and occupant satisfaction. The performance of each hybrid strategy and control algorithm in terms of providing adequate ventilation and its energy consumption and impact on thermal comfort will be assessed through experiments in the recently upgraded NRC ventilation research house facility for a full range of weather conditions.

A parallel study of hybrid heating, combining radiant floors and forced-air heating systems, is also underway in this facility (see Solplan Review, July 2006). This provides the opportunity to ensure that innovative hybrid ventilation strategies will be suitable for houses both with and without the good indoor air distribution that results from continuous low-speed operation of forced-air furnace fans (as shown by previous IRC research).

Ventilation rates and air distribution patterns will be measured under different modes of operation over a range of weather conditions and system operation states in order to assess the variability and reliability of ventilation as functions of these conditions. The energy consumption will be monitored for all strategies and operating conditions.

Results from the study will demonstrate the potential of hybrid ventilation strategies in houses for reducing energy consumption and peak electrical load, and improving building ventilation.

Participation by one or more manufacturers will improve collaboration between industry and researchers, and facilitate industry uptake of the technology developed.

The study results may lay the foundation for further development of residential strategies for free cooling, a proposed research topic for the near future.

Readers can obtain more information from these websites:

Hybrid ventilation research: *http://irc.nrc-cnrc.gc.ca/ie/iaq/factsheet8_e.html*

Research house facility:*http://irc.nrc-cnrc.gc.ca/ie/facilities/testhouse3_e.html*

Best Practices Guide to Residential Construction:

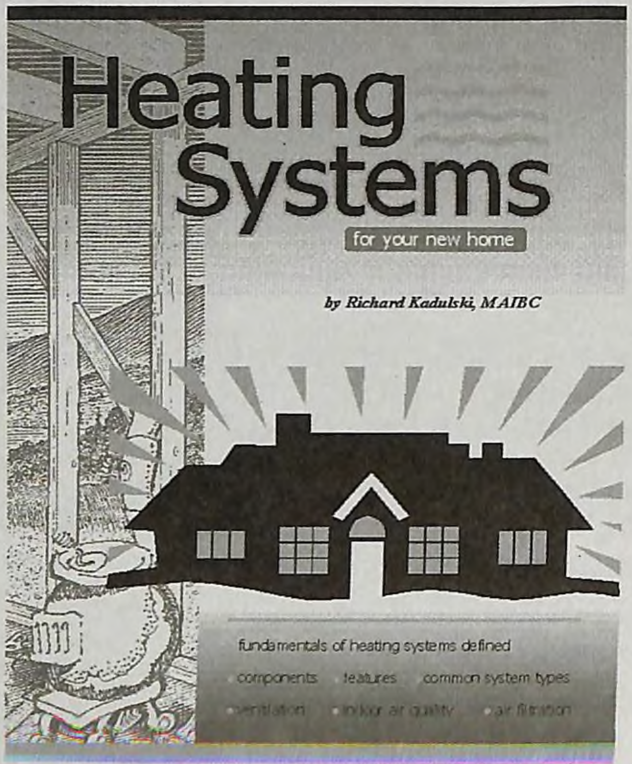
James Reardon is a Senior Research Officer and Boualem Ouazia is a Research Officer with NRC-IRC's Indoor Environment program.

Solplan Review Back issues

A limited number of back issues are available, at a special price of $5.50 each (plus 7% GST).

Bundle special: a random selection of back issues (minimum 22 copies) are available for only $60.00 (plus 7% GST)

Solplan Review
Box 86627
North Vancouver, BC V7L 4L2



Available Now!

Heating Systems
for your new home
by Richard Kadulski, MAIBC

Heating Systems for Your New Home is the book that explains heating system options for your new home.

Contents include:

- **Heating Fundamentals**
- **Heating System Types**
- **Features to consider**
- **Common system types described**
- **Overview of ventilation**
- **Filtration**
- And much more!

$19.95 Mail order: $ 23.49 ($19.95 + plus $ 2.00 shipping & handling + GST)

the drawing-room graphic services ltd.
Box 86627 North Vancouver, B.C. V7L 4L2
FAX (604) 689-1841
e-mail: solplan@direct.ca

SOLPLAN REVIEW is an independent Canadian Journal published 6 times per year to serve the needs of professionals and interested lay persons. It provides news, technical details, new product information, insights and commentary on developments covering all aspects of building science and energy efficient building practice for new and retrofit residential construction. Technical information is presented in a clear, concise manner without resorting to jargon.

SOLPLAN REVIEW is an independent subscription supported publication that relies on the support of readers. If you are seeing this journal for the first time, and find it valuable, why not ensure that you don't miss any copies. Subscribe today!

YES, I WANT TO SUBSCRIBE TO SOLPLAN REVIEW

In Canada: 1 year: $51.94 ($49.00 + 2.94) [NB, NS, NL $55.86 includes HST]
2 years: $93.28 ($88.00 + 5.28) [NB, NS, NL $100.32 includes HST]
USA and other foreign: 1 year $56.00 per year, 2 years $102.00 (USA and other foreign in US funds).
Pay by: VISA ☐ MASTERCARD ☐ AMERICAN EXPRESS ☐ CHEQUE/CHECK ☐

Card No ____________________ Exp date __________

Signature ____________________

NAME ____________________

ADDRESS ____________________

____

POST CODE ____________________

the drawing-room graphic services ltd.
PO Box 86627 North Vancouver, BC V7L 4L2
Fax: 604-689-1841
e-mail: solplan@shaw.ca

GST registration: R105208805